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ABSTRACT

The Zimbabe Secondary School Science Project (ZIM-SCI) developed student study guides, corresponding teaching guides, and science kits for a low-cost science course which could be taught during the first 2 years of secondary school without the aid of qualified teachers and conventional laboratories. This ZIM-SCI study guide includes activities and experiments for a two-part unit in which students investigate: (1) the role of food as a fuel; (2) three major food groups (fats, carbohydrates, and proteins); (3) the use of food as a fuel in living things; (4) characteristics and reactions of carbohydrates; (5) digestion; (6) breathing; and (7) photosynthesis. Information is provided throughout the unit to help students understand the scientific concepts behind the activities and experiments. (JN)

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ZIM-SCI

ZIMBABWE SECONDARY SCHOOL SCIENCE PROJECT

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YEAR 2

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STUDY GUIDE UNIT G1

Energy For Living

SE 043849

UNIVERSITY OF ZIMBABWE
AND MINISTRY OF EDUCATION AND CULTURE

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September, 1982.

ZIM-SCI

ZIMBABWE SECONDARY SCHOOL SCIENCE PROJECT

GENERAL SCIENCE

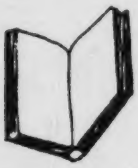
STUDENTS: Please read this carefully. It will help you.

How you will study

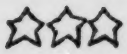
This Study Guide comes to you with a kit of apparatus. Both things are part of a study programme leading you to an understanding of aspects of science. In this course you will be carrying out experiments. The Study Guide will help you to understand the scientific principles behind the experiments.

Your work should be done as you are instructed, either by the teacher or the Study Guide.

To help you to see quickly what you must do, the Study Guide uses these symbols:



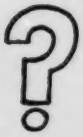
for "Read and revise your notes and Study Guide"



for "Take note of an important point that you should learn"

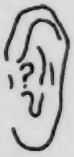
for "Summary. This is to help you to go over what you have learned"

for "Experiment"
When you see this sign, read the instructions carefully from beginning to end before you start to do the experiment.



for "How much do you know?"
This is for you, to help you to test whether you are remembering what is important.

for "Written work"
This is when you must answer questions in writing.



for "Listen to the teacher and do exactly what the teacher tells you to do"

for "Activity"
This symbol will appear whenever you are asked to do something without your apparatus.

CONTENTS

	Page
Aims of this Unit	3.
Experiment 1: To see if many kinds of foods burn	6
Activity 1: What did you eat yesterday?	9
Looking at different kinds of foods	9
Experiment 2: To find out what happens when a carbohydrate, such as sugar, burns	11
Experiment 3: To see if you give off carbon dioxide and water	14
Experiment 4: To see if we use up oxygen in the air	15
Definition of respiration	16
Experiment 5: To find out if germinating beans respire	18
More about carbohydrates	20
Experiment 6: Investigating different carbohydrates	22
Which of the foods we eat contain starch?	25
Experiment 7: To see if the starch can be changed to a simple sugar in a chemical reaction	26
Experiment 8: To see if saliva changes starch	29
Definition of an enzyme.	31
Diagram of the human gut	32
Activity 2: Making a model of the gut	33
Activity 3: Looking at intestines on the bioviewer	35
Experiment 9: Does yeast use up glucose to respire?	36
Activity 4: How do your lungs work?	41
How much do you know about food and its use in living things	45
PART II: Making food	
Von Helmont's Experiment	48
Experiment 10: Do plants take up carbon dioxide from the air?	51
Experiment 11: To see if starch is present in a leaf	53
Experiment 12: Do plants take in carbondioxide in the dark?	55
Experiment 13: To see if starch is made in a destarched leaf where light falls on it	56
Experiment 14: To find out if oxygen is given off when a plant is making food in the sunlight	59
The carbon cycle	61

CONTENTS continued

	Page
Experiment 15: To see if the green colour is important in the making of starch	63
Activity 5: Looking at the 'factory' inside a leaf	66
Activity 6: Finding out about the surface area of leaves	68
Activity 7: Comparing the tissues inside a leaf with the tissues inside a lung	71
How much do you know?	73
Summary	74

AIMS OF THIS UNIT

At the end of this unit you should be able to :-

1. Demonstrate and explain the release of energy from food by living organisms and compare it with the release of energy in burning.

2. Name some foods which contain mainly carbohydrate, protein or fat.

3. Identify two members of the carbohydrate group (simple sugar and starch) by tests.

4. Understand that carbohydrate molecules can be built up and broken down.

5. Describe and explain digestion in simple terms.

6. Name the gases exchanged from the air in animals and plants.

7. Describe and explain how the leaf and lungs work and are specialized for the exchange of gases.

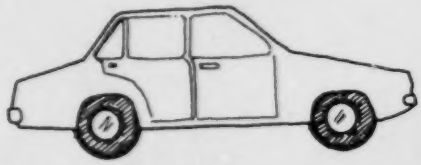
8. Name the conditions needed for photosynthesis to occur.

9. Describe and make diagrams to show the carbon dioxide and oxygen cycles.

THIS UNIT IS ABOUT HOW LIVING THINGS GET THEIR ENERGY

PART I ENERGY FROM FOOD

Each day there are lots of things you have to do. Doing things needs energy. Have you plenty of energy to do your work now? Good! In this new unit you are going to learn how you get your energy, and about the energy used by other living things. You have learned in Unit B about all kinds of energy such as potential or kinetic (moving) light, heat, and how they can be changed from one form to another.

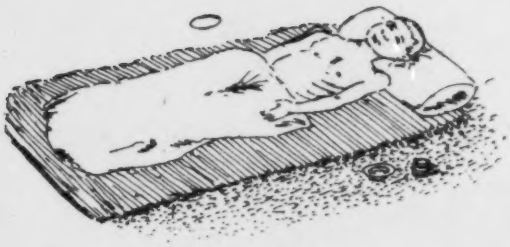


Car

You know that machines need stored fuel energy, such as coal or petrol, to do work. You will probably find it strange to think of living things needing stored fuel energy, to do work.

What kind of stored energy do living things use?
By the time you have walked to school, worked, played games and then walked home you are sure to be rather hungry. If you did not eat, would you feel like working for the rest of the day?

In countries where there has been a drought and the crops have failed, the children do not get enough food. They do not have much energy. They are thin and tired and want to lie down all the time. Because they do not get enough to eat, they are short of energy. The food we eat is the *"fuel"* that supplies our energy, just as petrol is the stored fuel energy that makes a car go.



In Unit B you have burned some mealie meal, which gave two forms of energy: heat and light. Mealie meal comes from the food store of the maize plant. You may often eat it as sadza (isitshwala). Do you also eat peanuts or bread, or have oil in your food? These also come from the seeds or food store of plants. We are going to find out if they contain stored energy too. Your teacher will give you a sample of one sort of food for Experiment I

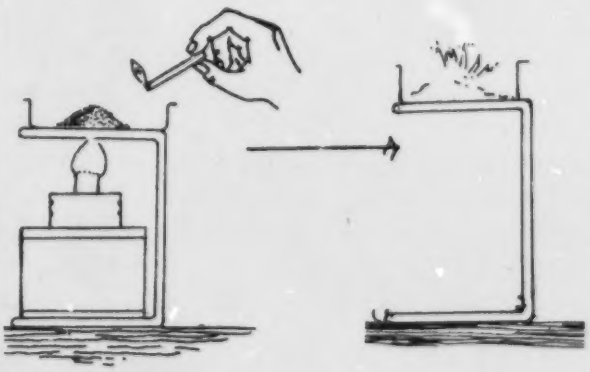
EXPERIMENT I : To see if many kinds of food burn

You will need :

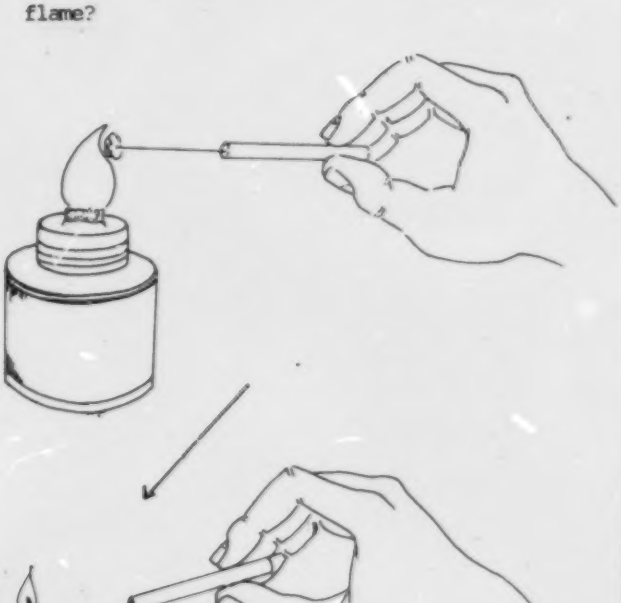
- burner
- burner stand
- evaporating dish
- mounted needle
- some food material: a piece of bread, some mealie meal, a few drops of oil, a peanut, or some sugar.

If you receive oil, or a powder such as mealie meal or sugar, follow instruction A. If you have bread or a nut follow Instruction B.

A. Fetch the material in your evaporating dish and place it on your burner st d. Heat it. Sugar should melt and become brown. Mealie meal should become bl l should start to smoke. When ned light it with a match. burner. Is the food burning me?

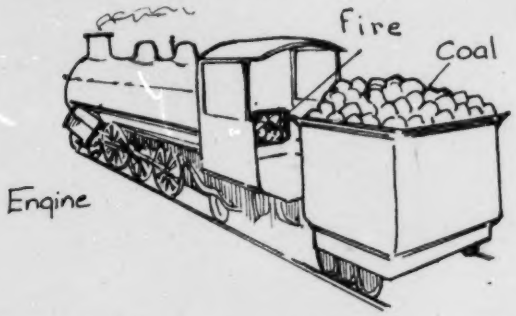


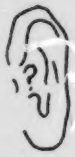
B. If you receive a peanut or piece of bread, fix it on the end of your mounted needle. Heat the food gently over the burner flame. It will first become dry and dark brown. Does it then start to burn with its own flame?



It seems that the foods we eat do contain stored fuel energy. (Remember the energy we gave to the food in the beginning of the experiment by heating was only to start the reaction.) If these foods are burned fast, as in Experiment 1 they give off lots of heat and light. That is not the way we want our energy. Some heat energy is useful to keep us warm, but we need most of our energy to do work.

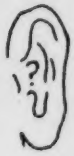
Remember that stored energy can be changed into any of several different forms. The engine of a train may use coal, and burn it to heat water to steam. This steam drives the wheels of the train giving work energy.



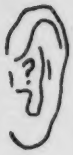


Think of other energy conversion chains you have studied in this course.

Living things are very special machines which use the stored energy in food in a different way. They release it slowly all the time by what we can call 'slow burning', with no flame, giving energy. You will find out how this happens later in the Unit.



Do we need energy all the time?
Keeping absolutely still, close your eyes and listen to your teacher.



We all need food to carry out the life processes of our bodies - which keep us alive. Naturally, when we are doing work, like running or digging, we need far more energy. Who needs the most food - an office worker or a farmer? Discuss this with your teacher.

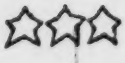
ACTIVITY I

What did you eat yesterday?

Your teacher will write on the blackboard a list of common foods. When your turn comes put a ✓ next to each kind of food which you ate yesterday. Add any other food you ate at the bottom of the list.

Looking at different kinds of foods

All the kinds of foods which we eat fall into three main groups, the members of each group being similar to each other chemically. The three groups are called:



THE CARBOHYDRATES

THE PROTEINS

THE FATS

Look at the picture below. It shows some examples of the foods which belong in these groups.

You can see from these pictures that the meat or eggs which you ate contained a lot of protein. The margarine on your bread was a fat, but the foodstuffs of which you ate the most, i.e. sadza, bread and sugar, were carbohydrates. To have a healthy diet we should eat some food from each group, some fat, some protein and some carbohydrate each day

What are Carbohydrates?

Carbohydrates all contain the same three elements. The name carbohydrate helps to tell you what these elements are. 'carbo' for Carbon, 'hydr' for Hydrogen, and the 'ate' at the end means that oxygen is present. You have learnt about these three elements before in Unit F2.

Experiment 1 showed you that a carbohydrate releases energy through a chemical reaction. In a chemical reaction a compound often breaks into other substances. In Unit C2 when you heated the iron-iodide compound you had made, it broke up into two substances: iron and iodine.

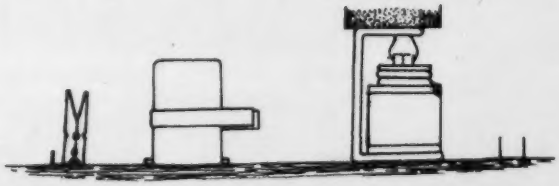
Now you are going to find out what substances the carbohydrate sugar breaks into when it is releasing energy.

EXPERIMENT 2 — To find out what happens when a carbohydrate, such as sugar, burns to release energy.

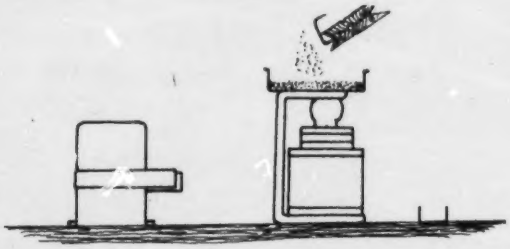
You will need:

- Boiling tin
- a long folded strip of paper to hold a hot boiling tin
- a 10 ml measure of sugar from your teacher
- evaporating dish
- a peg
- the small cap (lid) from a plastic bottle
- burner and burner stand
- the shiny spare burner lid
- matches (several)
- some purple bicarbonate indicator from your teacher

1. Set out your apparatus exactly as in the diagram.

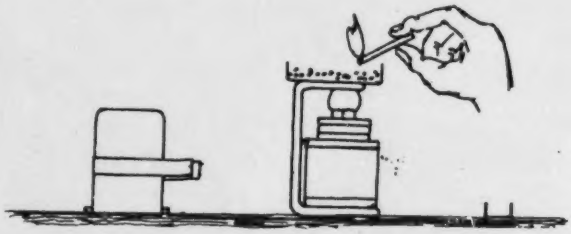


You will have to start off the chemical reaction by gently heating. Light your burner under the sugar. The sugar will start to melt after a few minutes. When it starts to bubble and turn brown, hold the shiny surface of the spare burner lid about 5 cm above the sugar. (Hold it with your peg so that you do not burn your finger). Count up to 5, then remove the lid. Examine the shiny surface. What does it look like?
Wave it in the air to cool it. Now touch the surface with your finger. What do you think is on the surface? Put this lid away.

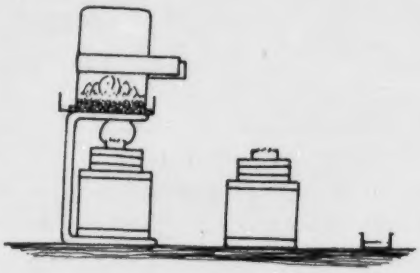


Your sugar will by now be brown. Hold the evaporating dish with the peg and move it around a little until all the sugar is a dark brown and is not bubbling so strongly.

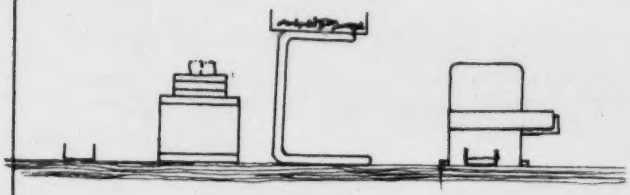
Take a match and light the sugar. It may not light first time, but it will eventually burn. When you see a flame coming from your sugar, remove your burner. It is now the sugar itself burning and giving light and heat-energy.



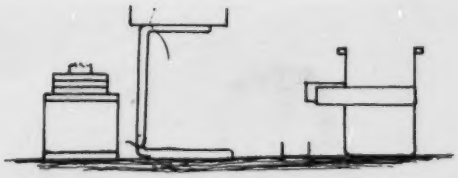
Holding the boiling tin upside down by the paper strip and carefully, cover the burning sugar. Count to 5.



Remove the tin, still upside down, and place it quickly over the cap of bicarbonate indicator.



What has happened to the flame on the sugar?
After 5 minutes uncover the cap of bicarbonate indicator
What colour has it become? What does this tell you?



Now answer Exercise I.

You have found out that when a carbohydrate burns, oxygen from the air is used up; carbon dioxide and water are given off and energy is released, in a chemical reaction.

☆☆☆

$$\text{Carbohydrate} + \text{oxygen} \xrightarrow{\text{reaction}} \text{water} + \text{carbon dioxide} + \text{energy}$$

Knowing these facts, you can investigate plants and animals to see if they are using carbohydrates as a source of energy. You cannot see a flame, but you can find out if the same sort of chemical reaction takes place by looking for carbon dioxide, water, energy, being given off, or oxygen being used up

Firstly let us see whether <u>you</u> give off carbon dioxide! Test the air which you breathe out in Experiment 3.

EXPERIMENT 3 To see if you give off carbon dioxide and water

You will need:

a straw
the small beaker ⅓ full of bicarbonate indicator
spare burner lid

a) Do you breathe out carbondioxide?
Your indicator should be purple. What does this mean?
Breathe <u>gently</u> through your straw into the indicator.
(If you blow too hard you will make a mess).

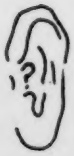
What colour does the indicator become? What does this tell you?

(b) Do you give off water when you breathe out?

Open your mouth wide and breathe onto the shiny lid. What do you find on the lid?

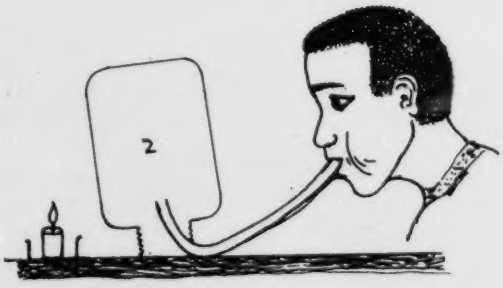
Now answer Exercise 2.

A candle or sugar needs the oxygen in the air to burn.
Do you use up oxygen in the air?
If you have used up the oxygen in the air when you breathe it a candle would not burn in that air.
Your teacher will investigate the air one of you has breathed.

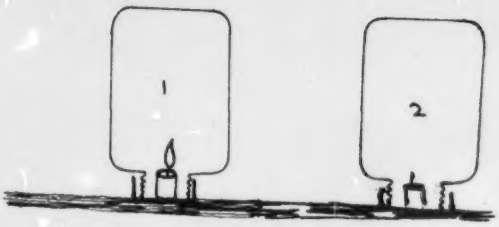


EXPERIMENT 4 To see if we use oxygen in the air.

Your teacher will do this experiment while you help.



One of the pupils will be asked to use up the air in a large bottle by breathing it three times.



You must time how long a candle will burn in the fresh air in one bottle.
Then time how long a candle will burn in the used up air.
Do you think breathing used up oxygen?

Answer Exercise 3

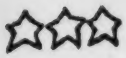
You have now seen that people use up oxygen and give off carbon dioxide and water vapour which shows that a type of burning takes place inside us.

Many reactions happen quickly, when they are heated, but slowly if they are not heated. They still give off as much energy, but it is slower. We have called this 'slow burning . If you take in carbohydrate you use it over a period of several hours continuously - releasing the energy for work and play and life processes as you need it.

When an organism takes in oxygen and uses it within the cells to break down carbohydrate molecules and release energy, it is said to be respiring. Carbon dioxide and water are usually given off as by-products

The process in which the chemical energy stored in food is released in the living cells is called RESPIRATION.

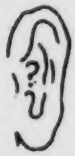
The process of respiration can be represented in this way:



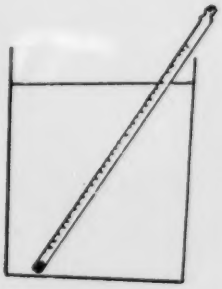
carbohydrate + oxygen ----->carbon dioxide + water + energy

(which is the same chemical equation as the one for burning of carbohydrate in air)

In many energy changes, heat energy is one of the products. For example, a candle burns to give light and some heat or a motor gives a kinetic energy with some heat. When we use carbohydrates to release energy for doing work, is some of this energy given off as heat also? Yes - you know if you run to school, you have done extra work and you feel uncomfortably hot when you arrive.



We use some of this heat energy to keep us warm. Your teacher will demonstrate this to you now.



<u>Do plants give off heat too?</u>

We know that bean seeds have a carbohydrate food supply to start their growing. (Remember Unit E2) We can't see them using energy the way we do, which is running and working! Do they use their carbohydrate as an energy source for growing? Are they respiring?

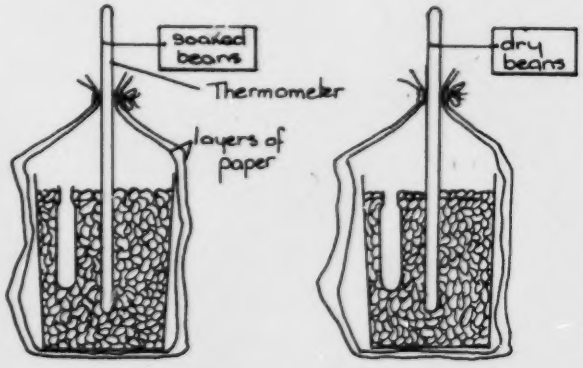
You will now use your knowledge of carbohydrates to give the answer to this question.

EXPERIMENT 5 To find out if germinating beans respire

You will need:

2 plastic cups
a handful of dry beans
a handful of soaked beans
2 thermometers
2 plastic bottles ½ full of purple bicarbonate indicator
a piece of aluminium foil
a piece of thread
some newspaper

Take two plastic cups, place a bottle of bicarbonate indicator into each. In one cup put soaked beans which your teacher will give you. Why have the beans been soaked? Take care not to drop the beans inside the bottle! In the other cup put ordinary dried beans. Why do you put dried beans in this cup? Cover the cups with aluminium foil. Push a thermometer through the foil into the beans. Tie a paper label on the thermometers, labelling one 'dried beans' and the other 'soaked beans'



Now wrap each cup in 5-6 layers of newspaper - why? Secure the paper with thread as shown in the diagram. Put the two cups together in a safe place.

Read the temperatures on each thermometer.
(You may have to push the paper down gently in order to see the reading)

Copy this table into your note books to fill in.

Table:

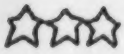
	Temp at start of exp.	Temp after .... days	Temp after .... days	Colour of bicarb. indicator after ..... days
Dried beans				
Soaked beans				

The next day, and the day after that, take the temperatures on both thermometers, writing them down on your table.
After about one week open up the cups. What do you notice about the colour of the bicarbonate indicator in each?
What does this tell you?

Answer Exercise 4

More about carbohydrates

You have studied some chemical reactions of carbohydrate foods.
You now need to learn more about some members of this group.
There are many kinds of carbohydrates. Here are some which are of importance to us.



1. GLUCOSE - a simple sugar.

It is a slightly sweet-tasting white powder. It is often fed to sick babies as they can use it easily to get energy.

2. SUCROSE - ordinary sugar

This is the sugar we use in our tea - it is very sweet tasting and comes in a crystal form. It comes from sugar cane. You may have chewed some cane stems yourself.

3. STARCH

This is found in most plant food stores. It is not sweet and it has very little taste at all.

4. CELLULOSE

We cannot use cellulose as a food - it is rather tough and is found in the cell walls of plants. Grazing animals, like cows, can use it as a food. Where there is a lot of cellulose, such as in tree branches, we use it as a fuel in our fires as it contains a lot of energy. It is the main building material of which a plant is made.

Remember that all carbohydrates are made of carbon, hydrogen and oxygen! They all burn to give carbon dioxide, water and energy.

If these carbohydrates are all made of the same three elements why are they so different?
When a simple sugar carbohydrate is made such as glucose, there is a chemical reaction in order to join up carbon, hydrogen and oxygen atoms into a compound.
A lot of energy is put into this reaction (rather like making bricks when a lot of heat and work have to be used to make the clay grains stick together).
This energy stays stored in the molecules.
Once the first small molecule of simple sugar is made it can be increased in size by joining two or more molecules together, (rather like a bricklayer cementing bricks together).
A molecule of simple sugar glucose can have another simple sugar molecule joined to it, making a molecule twice the size, called sucrose.
Many sugar molecules can be stuck together to make molecules of the carbohydrate STARCH.
Thousands of small molecules are needed to make the enormous strong cellulose molecules.
The different properties of the members of the carbohydrate group therefore depends on the SIZE of the molecules. Glucose, sugar and starch do not taste the same, but there are other tests to tell them apart. You will learn these now.

EXPERIMENT 6 — Investigating the different carbohydrates

Copy down the table the teacher will give you so that you can fill it in after you have done each test during the experiment. (Exercise 5)

You will need:-

- Spatula/stirrer
- Clean small beaker full of clean water
- 2 small plastic bottles and caps
- scalpel or razorblade
- some iodine solution (from your teacher)
- a clinistick (never touch the coloured part of a clinistick. Hold it by the transparent plastic end only).
- a sheet of paper
- a sample each of the different carbohydrates:
  - cellulose, a piece
  - starch ½ spatula full
  - sucrose (sugar) ½ spatula full
  - glucose ½ spatula full

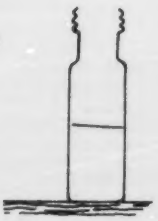
Your teacher will have these on the table at the front of the classroom.

a) Fetch some cellulose first. It will be a piece of dried plant material. Break it up into small pieces with your finger nails or scalpel. Do this over the sheet of paper. Put these pieces in a small bottle.

Half fill the bottle with water
Screw on the cap
Shake for 1 minute

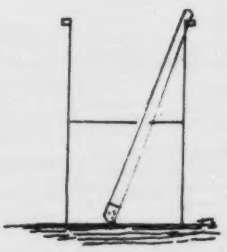
Take off the cap
Stand the bottle on your desk top
Examine it carefully

Can you see the pieces of cellulose, or have they dissolved?

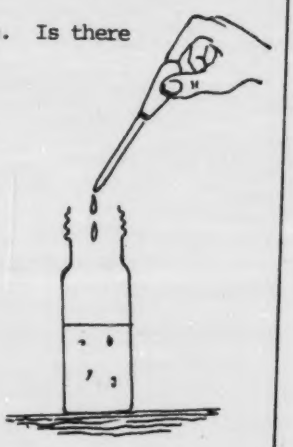


What colour is your Clinistick?
(It should be pink).
Now place the coloured end in your bottle
Leave it for 1 minute
Remove the clinistick
Look at the colour again. Has it changed?

Put the clinistick in the beaker of clean water until you need it again.



Now put a few drops of iodine in the bottle. Is there a change in the colour of the iodine?



Fill in your results for cellulose in your table.

Throw out the sample.

Wash out the bottle.

(b) Fetch a sample of starch powder in a bottle half filled with water. Screw on the cap. Shake for one minute. Take off the cap, place the bottle on your desk and examine carefully. Can you see some grains of starch, or is the liquid quite clear? Has the starch dissolved?

Put the clinistick in the bottle and wait one minute. Does it change colour? Replace the clinistick in the beaker of clean water.

Add a few drops of iodine. Does the iodine change colour?

Record your results for starch in your table.
Throw away the sample
Wash out the bottle well.

(c) Fetch a sample of sucrose in a clean bottle. Half fill the bottle with water, cap and shake as before. Remove the cap and examine - has the sucrose dissolved, or can you still see the sugar crystals? Test with the clinistick. Does it change colour. Replace the clinistick in the beaker of water.

Add a few drops of iodine. Does the iodine change colour?

Record your results for sucrose in your table.

Throw away the sample:wash the bottle.

(d) Fetch some glucose in your bottle. Half fill the bottle with water, cap it and shake for one minute. Remove the cap and examine the sample. Has all the glucose disappeared? Can you see any powder or has it dissolved?

Place the clinistick in the liquid and wait a minute. Now look at the coloured end. Has it changed colour?

Throw away the clinistick.

Add a few drops of iodine. Does the iodine change colour?

Record your results for glucose in your table

Throw away the sample and wash the bottle.

Answer Exercise 6.

Which of the foods we eat contain starch?

Your teacher will give you some samples of foods we often eat.

Work out for yourselves how to test them for starch. Ask your teacher for the apparatus and chemicals you need.

Write up your experiments and results. (Exercise 7)

You tested some of the foods which make up the main part of our DIET (the food we eat each day). You found that they contained mostly starch and you know that starch has big molecules and it does not dissolve in water.

Think back to Unit E1. Our bodies and those of other living organisms, are made of cells. Cells have a membrane around them which allows dissolved substances to diffuse in. These cells all need food to get energy to do their work. Starch cannot pass in as it is a big molecule and insoluble. The food supply should be in the form of small molecules which are soluble such as simple sugars which can enter the cells through the tiny holes in the membrane.

Read again about carbohydrates on page 20 . Large carbohydrate molecules are built up of the small simple sugar 'units'. A man could knock down a brick wall and make it into single bricks again - is it possible that large molecules could be broken down into small ones ?

EXPERIMENT 7 : To see if the starch can be changed to a simple sugar in a chemical reaction.

You will need

- a white lid
- iodine
- a boiling tin half full of water
- burner and stand
- small plastic bottle
- A peg
- some starch suspension in water
- 2 ml hydrochloric acid (be careful with acid)

large spatula full of sodium bicarbonate on a clean piece of paper

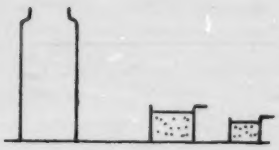
A piece of universal indicator paper

A clinistik

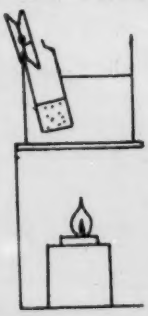
A small beaker of clean water

Put your water on to boil.

Put 5 ml starch suspension and 2 ml hydrochloric acid in your bottle.



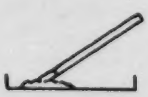
Put the bottle in the hot water and peg it in place. Leave to boil for at least 15 minutes.

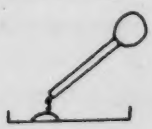


While the bottle containing starch suspension is being heated, fetch a few extra drops of starch suspension from your teacher on your white lid.

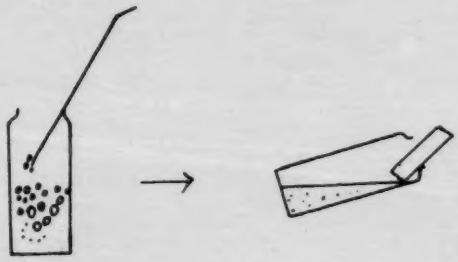
Test this starch with a clinistik. Does the stick change colour? What does this tell you?

Put the clinistik in the beaker of clean water to use again later. Add a drop of iodine to the starch on the white lid. What colour does it turn? What does this tell you?





Start to write up this experiment while the water is heating After heating the starch for more than 15 minutes remove the bottle from the boiling water. Blow out your burner. Using the stirring end of the spatula add a little of the sodium bicarbonate powder to your bottle. It will fizz as it reacts with the left over acid. Repeat this until the liquid does not fizz any more and a piece of universal indicator paper dipped into the liquid turns green. When this happens the liquid is neutral.



Now test the solution in your bottle with a clinistik. What colour does it become? What does this tell you?

Finish writing up the experiment
Answer Exercise 9.

You have seen that the starch solution has been changed during a chemical reaction. Large carbohydrate molecules can be broken down into small sugar ones again.
Can your body bring about this change too?

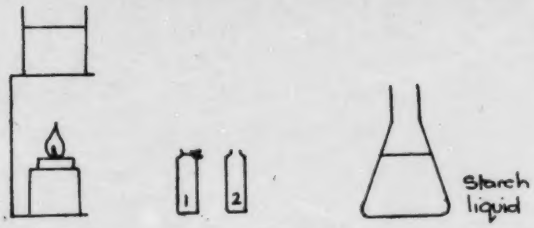
Why do we chew our food? Imagine chewing a piece of bread. We need to make it smaller and easier to swallow, but can you think what also happens to it in your mouth? What is in your mouth that is added to the food? Yes - spit of course. The proper name for spit is SALIVA. It comes from SALIVARY glands at the back of your cheeks. This makes the food more slippery so that it slides down your GULLET (the pipe which leads from your mouth to your stomach). Does the saliva do anything else which is useful? Next time you chew a piece of plain bread, chew it for a long time and see if the saliva changes the taste of the bread. You will now add some of your saliva to a starch suspension to find out the answer to this question.

EXPERIMENT 8 To find out what saliva does to starch.

You will need

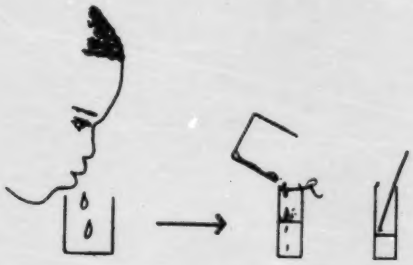
- a straw dropper
- 2 plastic bottles and caps
- a piece of thread
- some starch suspension
- some iodine
- a clinistik
- burner
- burner stand
- boiling tin ½ full of water
- thermometer
- small beaker of clean water
- plastic cup

Put the water on to heat.
Your teacher will put a table on the board for you to copy. (exercise 10)
Mark one bottle by tying a piece of thread around its neck - this is Bottle 1.
Leave the other bottle plain - this is Bottle 2.
Fetch some starch suspension (about 2 ml) in each bottle.

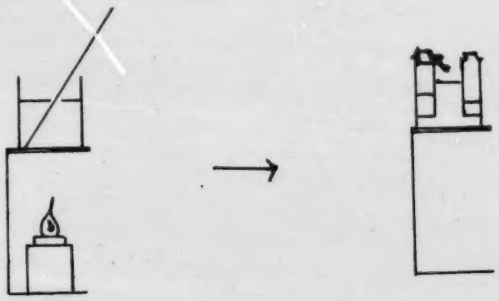


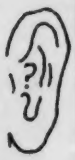
You and your partner should each put some saliva from your mouth into the plastic cup. Add this saliva to bottle 1. Cap it and shake it.

Bottle 2 should have no saliva. It is your control as it is only water and starch. Open each bottle and test with a clinistik. Is any sugar present? Put your clinistik in your beaker of clean water, and cap both bottles.



Take the temperature of the water in the boiling tin. It must be about 37°C for this experiment. You may need to heat it some more or add cold water. When it is about 37°C (why 37°C?) blow out the burner, place both bottles in the water and leave.





Your teacher will discuss with you why the temperature should be 37°C.

After some time, test the control bottle 2 with a clinistik. Note any colour change. Now test the bottle 1 (containing saliva) and note any colour change. Put a few drops of iodine in each bottle. Compare the colour of the control bottle with the colour in the bottle containing saliva.

Complete Exercise 10 and write up the experiment.

How does the saliva in our mouths bring about the chemical change? It cannot be dangerous hydrochloric acid! What is so special about it?

Our saliva contains a special substance called an ENZYME which helps break down large molecules of starch into smaller simpler molecules such as glucose.

☆☆☆

An enzyme is a substance which brings about a chemical reaction, without being changed itself by the reaction. An enzyme is SPECIFIC, which means it can only work on one kind of substance and is useless on others. The body has many different enzymes, each doing a special job - either building up or breaking down food molecules. You can see that enzymes are very important indeed!

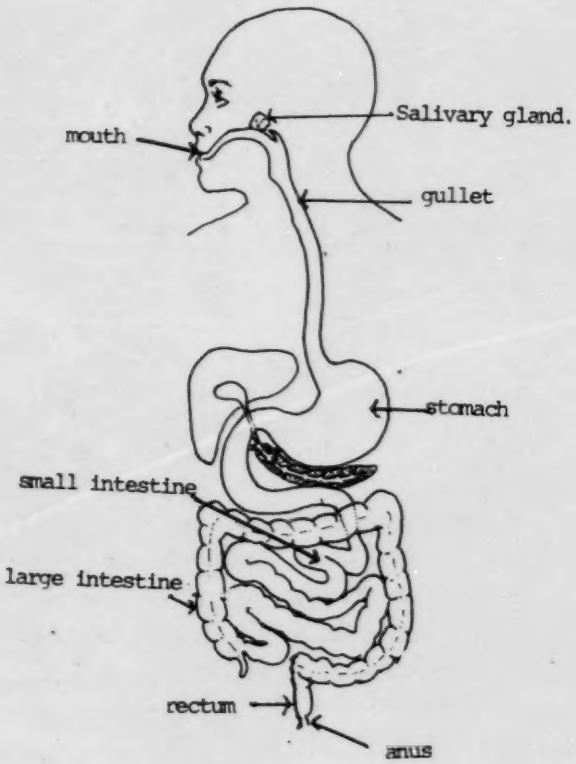
The enzyme in our saliva is called SALIVARY AMYLASE and is the first enzyme used in digesting our food.

The process of breaking down large food molecules into small molecules by using enzymes is called DIGESTION.

Teeth do not digest food, but help in the process by making the food pieces smaller for the saliva to spread into it easily. This is why it is very important to chew and mix your food with saliva before swallowing.

Some digestion takes place in the mouth as we have just seen. But most digestion of foods take place in the gut. Think of the gut you have seen in a chicken, or animal you have dissected. It was a long tube - thicker in some parts than others. Here is a diagram to remind you.

Diagram to show the gut of a person, and its parts



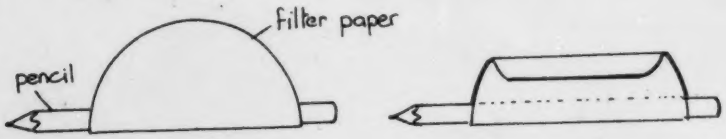
The GUT has two openings - one at the mouth and one at the other end, called the ANUS. To get into the body, the food molecules have to be very small so that they can pass through the cells in the wall of the gut. To help you understand this process you will now make a model of the gut.

Activity 2

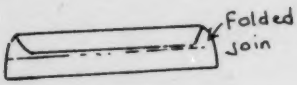
You will need;

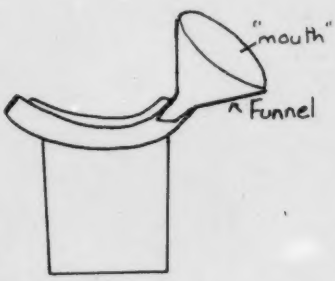
a piece of filterpaper
starch
glucose
a beaker ½ full of clean water
plastic cup
funnel
iodine solution
clinistik

To make a model gut fold the filter paper in half with a pencil or pen inside. See diagram
Now fold the two edges together over and over until you have a tube with thick folded join along one side.

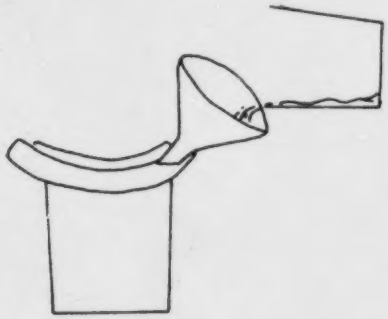


Take out the pencil and bend the tube getting into a "V" with the folded join on the top. Rest this model gut on your plastic cup which represents the body. Carefully put the funnel into one end to make a "mouth".

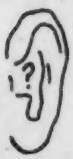




Mix a small spatula of starch and a small spatula of glucose in your beaker. This mixture will represent the partly digested food in your gut. Carefully pour the mixture through the mouth of the model.



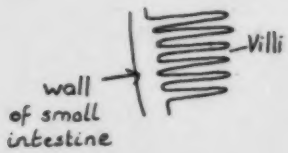
Quite soon you will see clear drops of liquid passing through the walls of the gut tube into the plastic cup body of the model. Test this liquid with firstly a clinistik and then iodine (You can best do this by allowing a drop to fall on the clinistik or a piece of paper with iodine solution on it).



Discuss the working of this model with your teacher.

Food which has large molecules must be broken down to small molecules in the gut. Substances which are not broken down pass out of the anus and are wasted!

The digestion of starch begins in the mouth. In the stomach and small intestines starch and other foods such as proteins and fats are acted on by different enzymes. You will learn more about this in another unit.
In the real body the food solution is absorbed through the intestine - that is the solution can diffuse through the cells lining the gut, into the blood tubes.
This process is helped by thin finger-like structures which stick out from the wall of the gut into the liquid food increasing greatly the surface area where diffusion takes place. These structures are called VILLI and are present in the small intestine



Activity 3A

You will need:

Bioviewer
Bioset ZS/3

Look at slides 4 and 5 and read about them.
Draw a salivary gland and the villi
Copy the picture of the cross section of an intestine (gut).

How do the small molecules of dissolved food which have passed through the walls of the intestine get to cells all over the body? In Zimbabwe we have a transport system. Trucks and trains are always moving along rail and road systems, collecting goods from places such as factories and delivering them to where they are needed. Animals like ourselves also have a transport system. Blood is constantly moving along small tubes, collecting food from the intestines and moving it around the body to the cells. (You looked at blood in Unit E and saw some blood vessels or tubes when you dissected a rat)

Cells getting energy from glucose

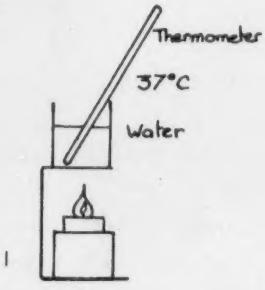
We cannot see our cells using glucose deep inside our bodies. We can however study some small plant cells, called YEASTS using glucose.
Your teacher will give you some yeast to do Experiment 9.

EXPERIMENT 9

You will need:

- 1 spatula dried yeast
- 2 spatulas glucose
- small plastic bottle
- 2ml purple bicarbonate indicator
- a plastic bag
- boiling tin
- plastic cup
- burner and stand
- spatula stirrer

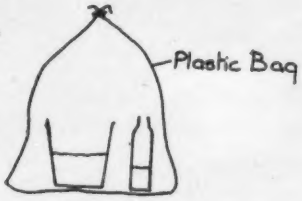
Heat some water until it feels just warm to your finger (that is about 37°C - the body temperature). Yeast is a living organism and like you does not work well when it is cold.



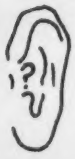
Pour the warm water into your plastic cup until it is about a third full. Add the yeast and glucose and stir well.

Place the cup in a plastic bag with your small plastic bottle containing the 2 ml bicarbonate indicator. Tie up the neck of the plastic bag.

2.



Leave in a warm place. Look at it after 15 minutes and again near the end of the lesson. What colour has the bicarbonate indicator become? What does this tell you?



In the meantime your teacher will have put a few drops of liquid containing some yeast cells on a slide for you to examine under the microscope.

Draw some yeast cells and write a description of your experiment.

Your teacher will keep one experiment from your class and test the solution with a clinistik in a day or two.

Answer Exercise 11.

Small organisms can obtain oxygen from their surroundings by diffusion - but how do larger animals get oxygen to their cells?

Special organs are needed of course. Insects have breathing tubes, fish have gills and land animals such as reptiles, birds and mammals have lungs.

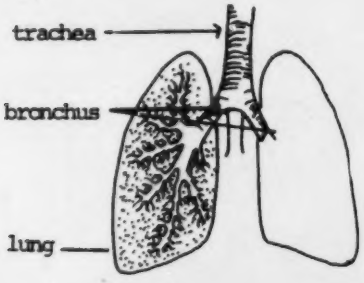
Did you see the two pink spongy lungs in the rat you dissected in Unit E1? You have a sponge in your materials kit which you can look at to help you understand more about lungs.

Activity 38

You will need your boiling tin ¾ full of water
The sponge from your materials kit.
Does the sponge feel light? and soft? Put it in the water. Does it float? Hold it underwater and squeeze it. What comes out? Does it decrease in size?
Take it out and squeeze again over your tin.
Look at it carefully. Is it solid? What is it like? What is inside the spaces? Like the sponge your lungs have a lot of air inside them. There are many air spaces. Sponge material has a *large surface area around small air spaces.* A large surface is needed to be in contact with air so that enough oxygen can diffuse from the air into the body. The surface area of your lungs is equal to the floor area of 4 or 5 classrooms! If you don't believe this is possible, try crumpling up a sheet of newspaper. That big surface area can fit into a ball the size of your fist.

Learning about your breathing organs

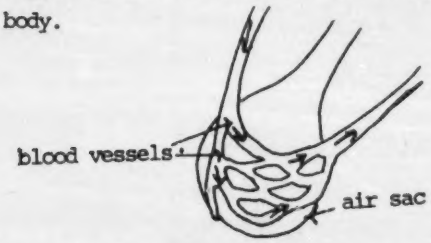
You breathe in through your mouth or nose, and the air passes down through a tube called the TRACHEA. This tube is kept open by rings of stiff tissue. You can feel these now with your fingers at the front of your throat. The trachea divided into 2 tubes, called BRONCHI (singular bronchus). Each bronchus leads to a lung.



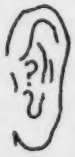
Within the lungs the bronchi divide again and again - like tree branches. The tubes become smaller and smaller and eventually end in millions of tiny balloon-like structures called AIR SACS like the small air spaces in a sponge.

These tiny air sacs have very thin walls which are always damp.
The breathed in or INHALED air has plenty of oxygen which dissolves in the moisture on the surface of the air sac.

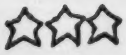
An air sac of course can only be seen under the highest magnification of your class microscope. This diagram is greatly magnified.
A network of tiny blood carrying tubes, called BLOOD VESSELS is fitted around the air sac. This is part of the blood system which carries oxygen as well as food to all the cells of the body.



The blood coming into the lungs from the rest of the body has little oxygen Dissolved oxygen from the air in the air sac moves through the wall of the air sac and blood vessel, into the blood and is carried away to cells of the body. There it is used by respiring cells to break down glucose and release energy. At the same time, carbon dioxide from this reaction is brought from the cells to the lungs. There it diffuses out of the blood, into the air sac and is breathed out or EXHALED.
This is why your exhaled breath turns the bicarbonate indicator yellow.



Your teacher will ask one of you to come up and make a model of the blood vessels and an air sac.



It can be said that the gases oxygen and carbon dioxide are EXCHANGED in the lung.

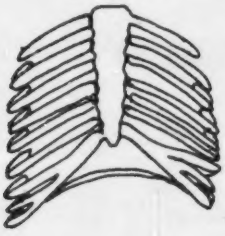
Activity 4

How do your lungs work?

The oxygen in a lung full of air would be quickly carried away, so the air needs to be changed. You do this all the time, and don't even think about it!

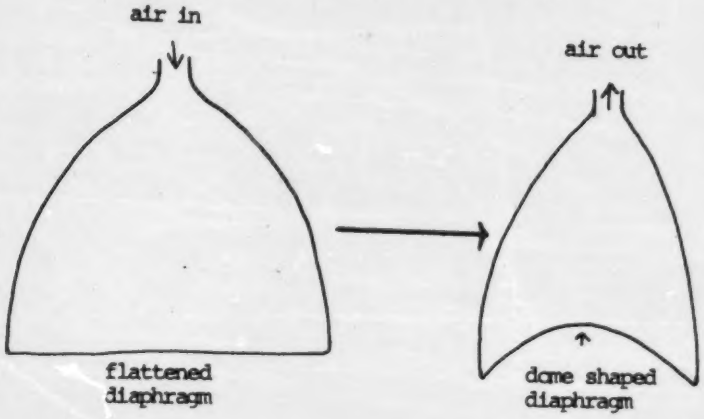
How does it happen?

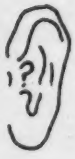
Your lungs are inside a cage, made of RIB BONES. The bottom of the cage is a thick sheet of muscle called the DIAPHRAGM. Feel your ribs now, they are thin bones which start at your backbone and move around to join in the front of your chest the ribs form a "cage."



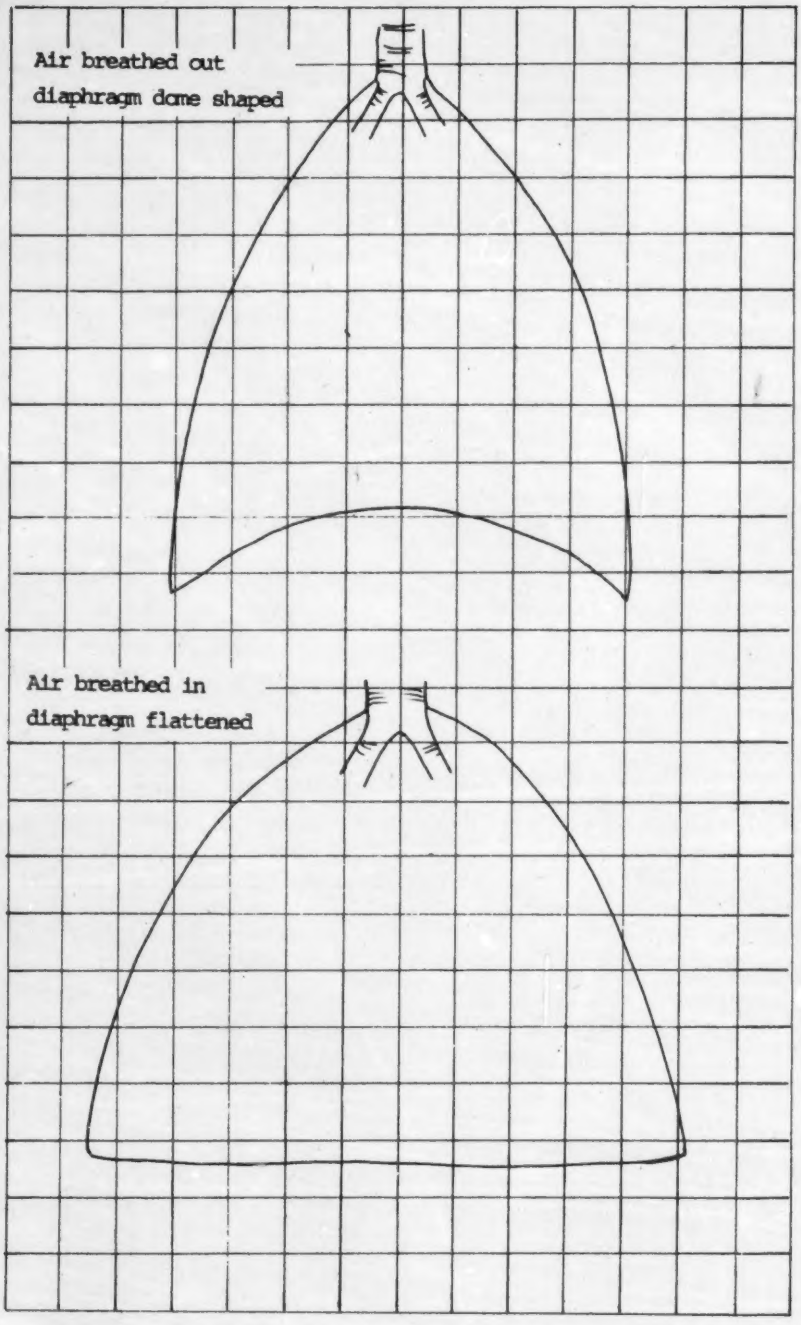
Put your hands on the sides of your ribcage. Breathe in. Feel how your ribs move outwards and upwards. See diagram.

As you breathe in your ribs are pulled up and out by rib muscles and your diaphragm pulls itself flat. Now let the air out of your lungs.
You can feel how your ribs fall in toward your body. Your diaphragm also relaxes as in the picture and is pushed into a dome shape.

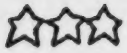




On the opposite page our artist has drawn two pictures on squared paper. Count the number of squares in each picture. How many squares are there in the chest space where air has been breathed out? How many squares are there in the second picture where air has been breathed in? When you breathe out, the volume of the space inside the rib cage decreases causing air to be pushed out of your lungs. Why? When you breathe in, the space inside your rib cage increases, causing air to be pushed into the lungs. Why? (Think about the changes in pressure and your work in Unit C2.)
In this way air is constantly passing into your body, some of the oxygen from it (about a quarter) being carried away from the lungs to the cells in each breath.


Air breathed out
diaphragm dome shaped
Air breathed in
diaphragm flattened

Remember:



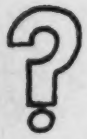
Breathing is the physical process by which air is taken into and out of the body.

Respiration is the chemical process by which organisms obtain their energy from food.

Do not confuse Respiration with Breathing!

You should now revise and see how much you know.

HOW MUCH DO YOU KNOW ABOUT FOOD AND ITS USE
BY LIVING THINGS?



Part 1.

1 The _____ living things use to get their energy is _____

2 Food contains _____ energy

3 When we fast burn food it gives _____ and _____ energy

4 When food is burned slowly inside living things we get _____ and _____ _____ energy

5 Some examples of life processes are :-

6 A _____ needs more food than a _____

7 There are 3 main groups of foods, the carbohydrates the _____ and the _____

8 We get most of our _____ from the carbohydrates.

9 Carbohydrates are a group of chemical fuels which are made up of three elements _____ _____ and _____

10 When carbohydrates burn a chemical reaction takes place and _____ is released. _____ and _____ are also given off

11 Bicarbonate indicator is a test for the presence of _____ when it turns from purple to _____

12 The chemical formula for burning carbohydrate is

_____ + _____ reaction _____ + _____

+ _____

13 People give off _____ and _____ when they breathe out

14 People use up _____ from the air they breathe

15 Plants seeds give off _____ and _____ when they germinate and start to grow.

16 The process by which chemical energy stored in _____ is released in the living _____ of an organism is called _____

17 Four important members of the carbohydrate group are _____ _____ and _____ _____

18 _____ has the smallest molecule and is soluble.

_____ has the largest molecule and is not soluble.

_____ has 2 simple sugar molecules stuck together.

19 _____ turns iodine blue black

20 A clinistick turns purple when dipped in _____ solution.

21 A substance in our bodies which breaks down large food molecules into small ones is called an _____

22 When we chew our food, _____ is added to it containing the amylase which breaks down _____ to _____

23 The gut starts at the mouth and ends at the _____ In between there are the _____, _____ , small _____ large _____ and _____.

24 Food passes _____ through the walls of the gut into the blood vessels by the process of _____

25 The surface area of the gut is increased by finger-like _____.

26 In single celled yeasts, no gut is present, but enzymes break down _____ to give _____ and _____

27 The blood system causes _____ from the intestines to the cells, _____ from the _____ to the _____, _____from the cells to the lungs.

28 Breathing is a _____ process

29 Repiration is a _____ process

30 Exhaled air has a more _____ but less _____ than inhaled air.

31. When a person inhales, air passes down the _____ which branches into two _____ these divide again and again ending in _____

32. The lungs are within a cage made of the _____ and the _____

33. The 2 gases exchanged in the lungs are _____ and _____

PART II MAKING FOOD

In part one you learned how living things get their energy from carbohydrates. There are carbohydrates in the food stores of plants - such as their seeds. People and other animals get their food by eating the plant food stores. How do the plants get food when they do not eat? Perhaps they make it?

Nearly three hundred years ago, a Flemish scientist named Von Helmont began to wonder where plants got food material from, in order to grow. He wondered whether the roots took substances from the soil and he designed an experiment to try to find this out.
This is what he did:

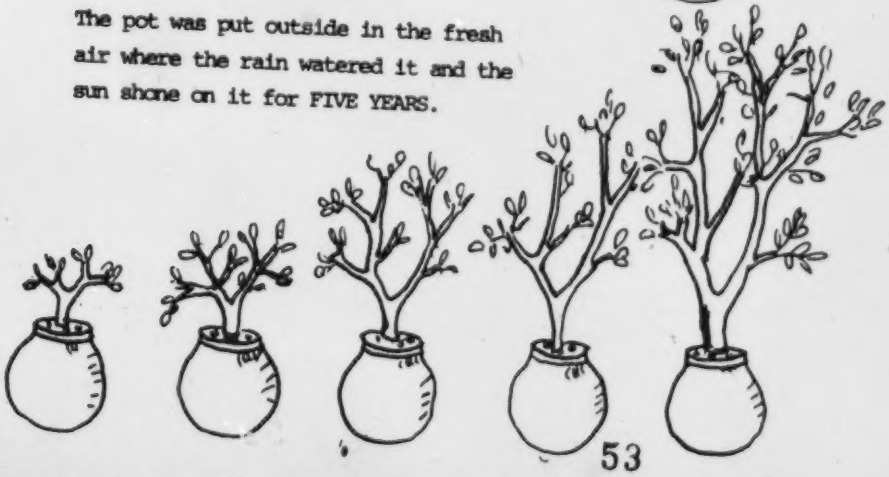
Von Helmont's Experiment

He took a pot
and filled it with 50 Kg of
dry soil

He fitted the pot with a lid
with a central hole and a
few small holes.

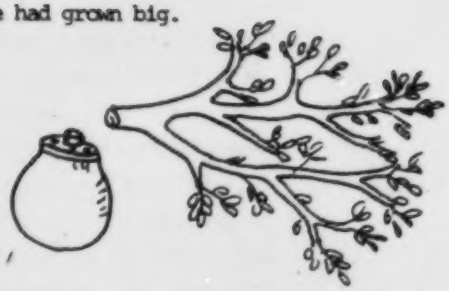
He took a tiny tree and weighed it.
It had a mass of 1 Kg. Then he planted
it through the middle hole in the lid.

The pot was put outside in the fresh
air where the rain watered it and the
sun shone on it for FIVE YEARS.



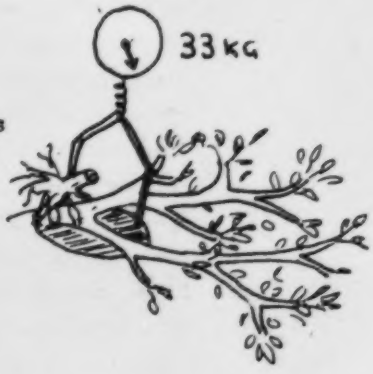
After five years the tree had grown big.

He had to chop it down



He removed the roots from the pot,
shaking off
all the soil back into the pot

He weighed the tree and its roots
It now had a mass of 33 Kg.



He took all the soil, dried it
and weighed it again. It was almost the
same mass as at the start of the experiment.

He discovered that the plant had used up hardly
any soil. There was almost the same mass of
soil left after the tree had grown as there
had been to start with. If a plant does not
use the soil to grow, what does it use?
Von Helmont thought it used the rain water.

What do you think?

Answer Exercise 12.

Von Helmont decided that the plant was able to get all the necessary elements for growing from rain water. He was partly right because water does contain oxygen and hydrogen. But you know that the cellulose and other carbohydrates in the tree contain carbon as well. There is too much carbon in the plant to have come from that tiny loss in mass from the soil.
So the carbon could not have come from the soil.
Where could it have come from?
What else was available to the plant?

It had water, and the air around it. Think back to your earlier lessons on air in Unit F2.
Air is a mixture of gases - do any of these contain carbon? Yes - carbon dioxide does of course!
This has carbon in it and oxygen.
Perhaps this is where the plant gets its carbon from.
There is very little carbon dioxide in the air but the plant has a lot of surface area held out in the air, which blows past it all the time, so it could be taking in a little all the time. This may be a source of carbon. In this unit you will carry out experiments to test this possibility. Scientists use the word HYPOTHESIS when they talk about an idea for which they are trying to find evidence.

You are going to test the hypothesis that "carbon in living material comes from the atmosphere."

Experiment 10

Do plants take up Carbon dioxide from the air?

You will need:

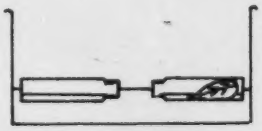
- 2 plastic bottles
- some leaves of a plant to fit in a bottle
- 10 ml bicarbonate indicator from your teacher
- 1 candle
- 1 evaporating lid
- your small boiling tin

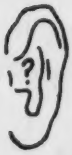
Place 5 ml indicator in each bottle, leave the caps off.
Place the candle on the lid, with the 2 bottles next to it as in diagram

Light the candle. Place the boiling tin over the bottles and candle. Leave for 2 minutes. When you remove the tin you will find the candle has gone out (why?)

What colour is the indicator in the bottles?
Why? Can you explain this?
Cap one bottle. This is your control.
What is a control for? In the other bottle place a piece of plant material. If you are using one leaf the same length as your bottle, curl it so that the upper surface of the leaf is on the outside.

Your teacher will have put a bath of cold water outside. The cold water is to prevent the bottles becoming too hot. Why?
Place the bottles in the bath of water outside.
You will need to look at them again near the end of this lesson.





Discuss this experiment with your teacher.
Then start Exercise 13 .

This experiment may take longer than one lesson.
Come back and look at it in break time or after school before you go home. Then complete Exercise 13

We tested leaves to see if they took in carbon dioxide.
If they do then they should be using it to make carbohydrates in a chemical reaction.
You will investigate leaves in the next experiment to see if carbohydrates are being made there.
If they are, you will have found the plant's 'carbohydrate factory'

The carbohydrate you are going to look for is starch.
Do you remember the test for starch?

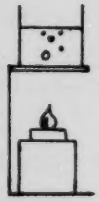
As a leaf is a dark colour and has a wax covering you cannot test it for starch with iodine as it is.
First you have to kill it, with boiling water, and then you have to take out the colour with methylated spirits, so that you can see the iodine effect properly.
Follow the diagrams step by step when you test a leaf for the presence of starch in Experiment 11.

EXPERIMENT 11 : To see if starch is present in a leaf

You will need

- a small soft green leaf (not a grass leaf)
- burner and stand
- small plastic bottle ½ full of meths
- boiling tin ½ full of water
- peg and forceps
- white plastic lid
- stirrer/spatula
- some iodine solution from your teacher

1 Put the water on to boil.
Go and get a soft small leaf.
A leaf from your bean plant will do



2. Put the leaf into your boiling water for one minute.
This will kill it and break open the cell walls.
Fetch your meths.

3. Remove the leaf with your stirrer and put it in the bottle ½ full of meths. Blow out your burner, as when meths gets hot it evaporates quickly and could catch fire.

4. Place your bottle in the boiling tin of hot water.
Hold it in place by pegging it to the side of the tin.
Leave for at least 10 minutes.

5. The Meths should remove the green colour from the leaf. When the leaf is almost white, remove it from the bottle (You can save the meths by putting it into your burner)

The leaf will be stiff, soften it by putting it back in the hot water for a minute.

6. Take it out of the hot water and spread it out on the white lid.
Go to your teacher and get several drops of iodine on the surface of your leaf.
What colour does it become?

What does this tell you?
Now do Exercise 14

Now we know that a plant has starch in its leaves which appear to be the starch factory. We also know that a plant takes in carbon dioxide and water. It seems very likely that these are the supply of the 3 elements carbon, Hydrogen and Oxygen, needed to make starch. How then does the plant combine them in its starch factory to make the carbohydrate compound?
The plant must cause a chemical reaction to occur the product being starch.
You have already seen that a chemical reaction requires energy to form a new product.

Where does the plant get the energy to cause the reaction?

Looking for a clue to the source of energy

When you did the last experiment you put the plants out in the sun. Perhaps sunlight is the source of energy (as in the solar cell).
What do you think would happen if we put plants in the dark?

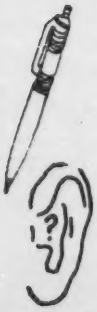
Experiment 12

Do plants take in carbon dioxide in the dark?

You will need:

1 plastic bottle with yellow bicarbonate solution (saved from Experiment 10)
another two leaves from your bean plant

Put both leaves into the bottle of indicator with the stems in the liquid. Put the cap on and place the bottle in the dark place provided by your teacher until the next lesson (at least 24 hours)



Complete Exercise 15,

Discuss this exercise with your teacher.

You have made some interesting deductions about the energy needed for starch production. This next experiment will test all these deductions.

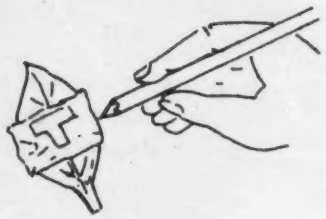
EXPERIMENT 13 . To see if starch is made in a destarched leaf where light falls on it.

You will need:

Your other destarched leaf in the bottle
a piece of aluminium foil
your burner and stand
some meths
some iodine solution
boiling tin ½ full of water
small plastic bottle
white plastic lid

Take the leaf out of the bottle and place aluminium foil around part of it, in such a way that some of the leaf is covered, and the rest is open to the sunlight.
You can do this in one of the ways you see in the picture.

(See that the foil is wrapped around the back of the leaf too). Draw a diagram of the leaf in its foil so that you can recognise yours again.



Now float the leaf right side up on the water in the bath which your teacher has placed outside in the sun. You will need to leave it then for an hour or two.

At break time or lunch time collect your leaf from the bath and go to the classroom. Your teacher will have some water boiling. Put your leaf in the boiling water for about 1 minute to kill it. Why? (Discuss this with your teacher.) Remove it, put it in a piece of paper and keep it safely for the next lesson.

(You will finish this experiment in your next lesson.)

In the next lesson remove the foil from the leaf.

Test the leaf as in Experiment 11 First drop the leaf in hot water, then boil it in meths to remove the green colour. Soften it again in hot water. Spread it out on a white lid and drop some iodine solution over the leaf surface. Compare the blue black parts of your leaf to the diagram you made when it was partly covered with the foil.

What does this tell you?

Answer Exercise 15

We can make a chemical sentence for this reaction from what we have found out so far.
Carbon dioxide + water + light energy $\xrightarrow{\text{reaction}}$ carbohydrate

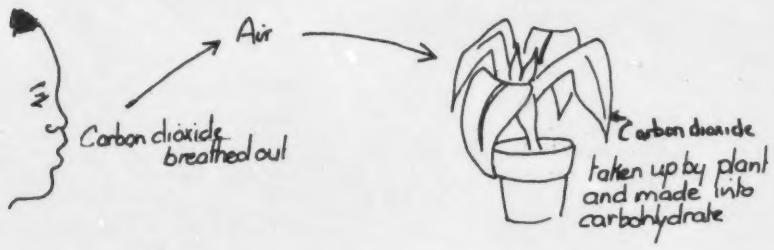
We can see that the carbohydrates which we eat contain the sun's energy - or "solar energy"
The product of the reaction (carbohydrate) is used by us during respiration to provide us with energy.
This as you remember can be represented with the chemical equations.

Carbohydrate + oxygen $\xrightarrow{\text{reaction}}$ carbon dioxide + water + energy.

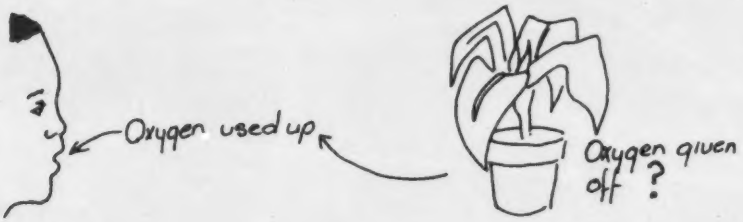
If you compare the two equations you will notice that respiration (or food breaking down equation) seems to be the reverse of the food making equation. Are these exactly opposite? If not, what seems to be missing in one of them?

You have found that burning and respiration use up oxygen, produce lots of carbon dioxide. Yet the amount of carbondioxide and oxygen in the air remains the same. Why doesn't it change?

In making food we noticed the carbon dioxide was removed from the air by plants. So the amount of carbon dioxide is kept even. As it is produced by fires and breathing, it is used up to make carbohydrates.



Is food the only product formed in the reaction?
Could it be possible that oxygen is also produced?



If so, the amount of oxygen in the air would also be kept the same.

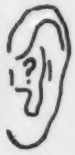
Let us test this hypothesis in an experiment.

EXPERIMENT 14 To find out if oxygen is given off when a plant is making food in sunlight.

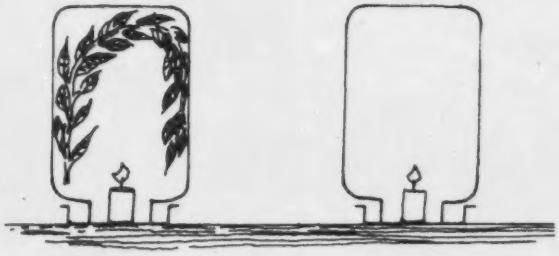
Your teacher will do this experiment while you watch and help.

Bottle 1 contains a plant.

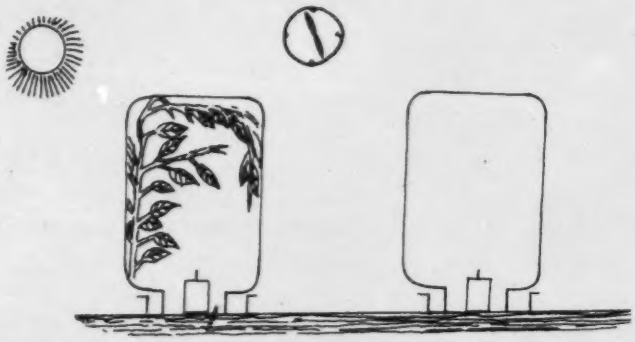
Bottle 2 is the control for this experiment and does not contain a plant.



The candles are lit to use up the oxygen in both bottles



The bottles are placed outside in the sunlight for up to an hour.

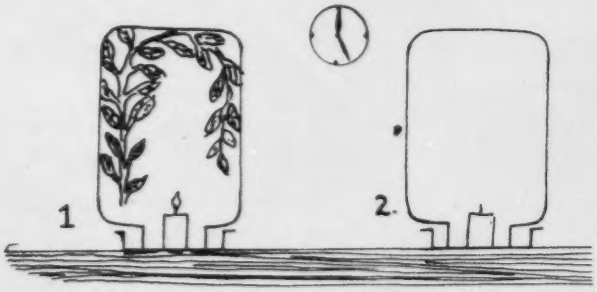


The candles are lit again in both bottles.

Time for how long the candle burns in Bottle 1.

Time for how long tha candle burns in Bottle 2.

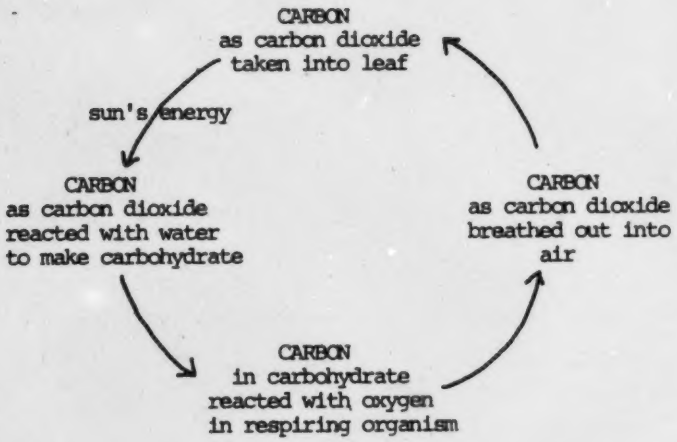
What does this tell you?



Now write up this experiment and your conclusions in Exercise 16

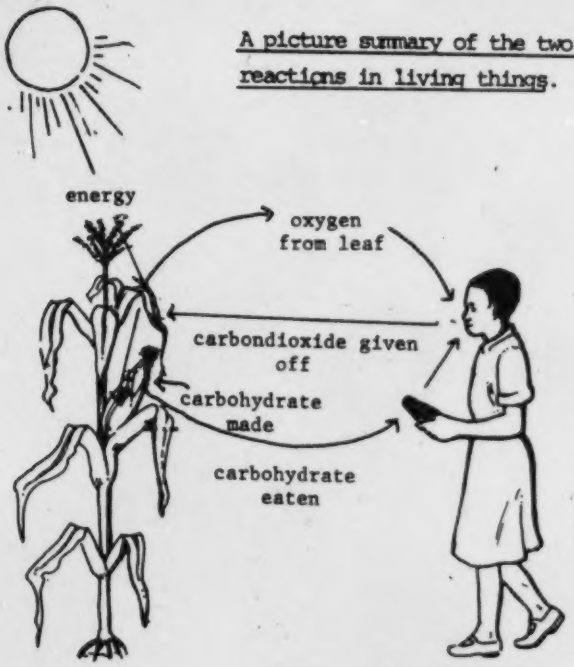
Do you remember the water cycle in Unit D, and the life cycles in Unit E2? A cycle means that something starts off, travels around and comes back to the same form or place. This happens to carbon in living things, and here is a diagram to show the cycle of carbon.

THE CARBON CYCLE



Answer Exercise 17

If you think about what you have learnt, you will realize that oxygen too is cycled. You should now try to make a diagram of an oxygen cycle. (Exercise 17



A picture summary of the two most important reactions in living things.

You now know the two most important reactions in living things.

The food making reaction which traps and stores the sun's energy at the same time releases oxygen.

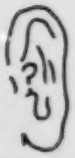
The respiration reaction which breaks down the food to release the stored energy for living. In this process carbon dioxide is released.

These two reactions keep the amount of oxygen and carbon dioxide unchanging in the earth's atmpsphere

What is so special about plants that they can make their own 'ood, and animals cannot? They trap light energy which no animals can do. How do they do this? Does a simple looking leaf have something wonderful in it that can catch and keep the energy of the sun - rather like your solar cell? What common characteristic do leaves have? Yes, that is right most are green!

Perhaps it is the colouring in a leaf which absorbs the light energy?

In order to test this hypothesis you are going to use a special leaf which is not all green. This sort of leaf is called a VARIEGATED LEAF. Why should we use this special leaf?



Discuss with your teacher.

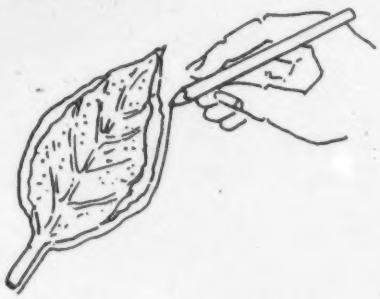
EXPERIMENT . 15, : To see if the green colour is important in the making of starch.

You will need:

- burner
- burner stand
- peg
- poiling tin ½ full of water
- matches
- white lid
- straw dropper
- iodine solution from your teacher
- small plastic bottle ½ full of meths from your teacher
- stirrer
- a variegated leaf (green and white)
- forceps/tweezers

1. Put the water on to boil.

2. Make a diagram of your leaf. Place it on your book and draw around it to get the outline, Carefully draw in the areas which are green and those which are white by shading the green areas with your pencil. Label them.



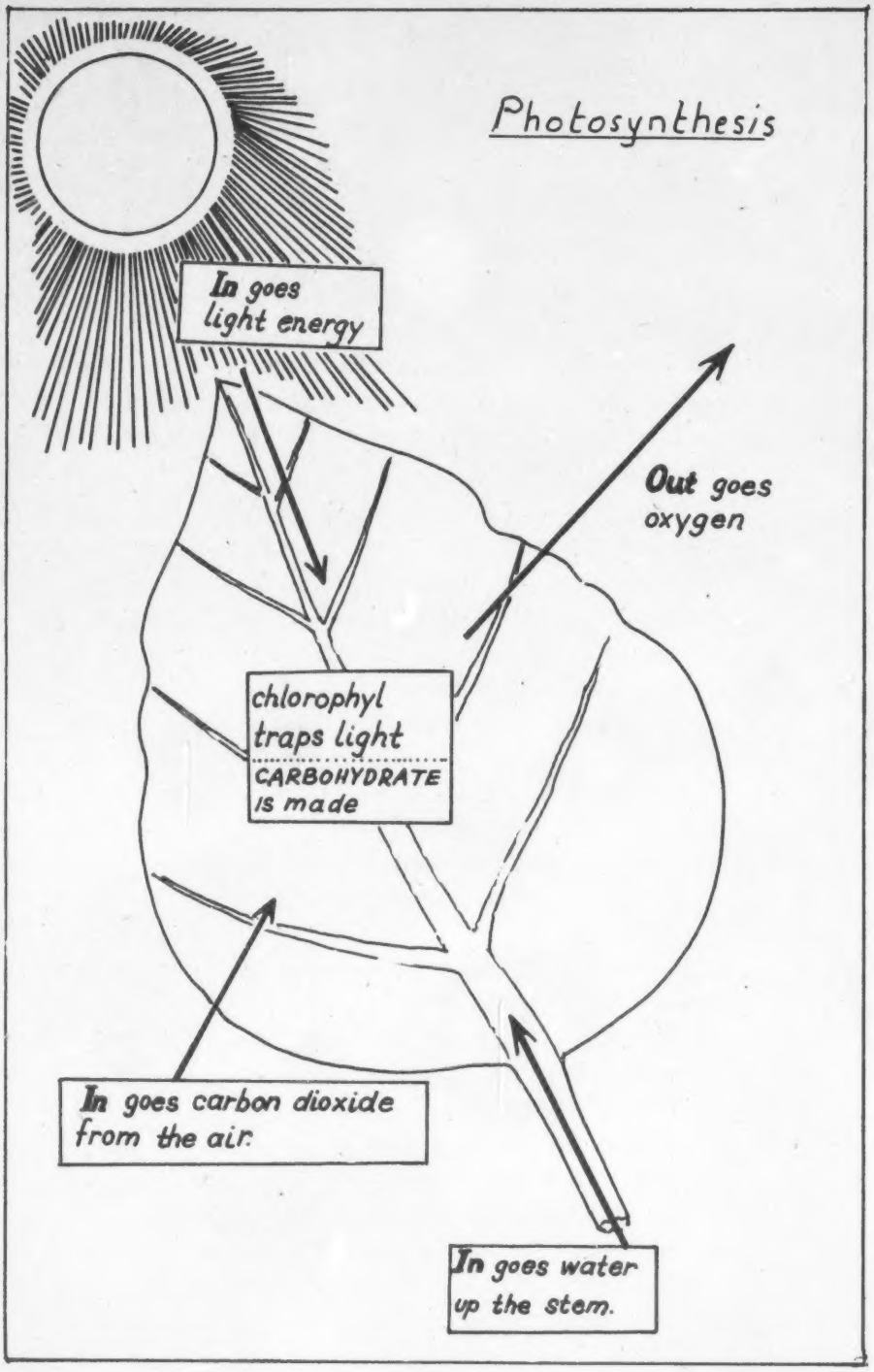
3. Test the leaf for starch as you did in experiment ...

4. Examine the leaf. Is it blue black all over? Compare it with the diagram you made in the beginning.

Answer Exercise 18

This important green colouring matter in plants which traps the light energy is called CHLOROPHYLL.

This food making process is called PHOTOSYNTHESIS Photosynthesis is the process by which carbohydrates are made by green plants from carbon dioxide and water using light energy. (photo means light, synthesis, made).


Photosynthesis
In goes light energy
Out goes oxygen
chlorophyl traps light
CARBOHYDRATE is made
In goes carbon dioxide from the air.
In goes water up the stem.

LOOKING AT THE "FACTORY" INSIDE A LEAF

Activity 5.

You saw in Unit E1 that a plant stem is made up of many cells. A leaf too has specialised cells. These cells contain the small blobs of green colouring chlorophyll which trap light energy.

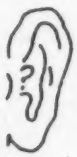
1 Study the cells inside the leaf on Bioset Slide 1 which is a thin slice through a leaf.

Read about it on the Bioset.
Draw the inside of the leaf, labelling the cuticle, pallisade cells, chloroplast, spongy cells, vein and epidermis. Make notes on the uses of these cells.

2 Look at Slide No. 2 and draw a pallisade cell. Label the cell wall and chloroplast. Read about it on the Bioset. Write down what sort of cell you think "2" is?

3 Carbon dioxide and oxygen gases need to pass in and out of a leaf for it to photosynthesise and respire. But all the cells are filled with water, which can be lost easily through the cell membranes. How does the plant solve the problem of letting in enough air without drying out?
It has a waterproof wax layer on its surface - called the CUTICLE to keep water in.
It lets air in and out through small holes in the epidermis called STOMATA (singular STOMA).

Examine the STOMA under the bioviewer Z52 Slide 3 Read about it and draw it.
Your teacher may have some real plant material to show you under the microscope.



4 You know from Von Helmont's experiment - and your own experiences in life that plants will not grow without water. In Science you have learnt that water is necessary to keep a cell s shape and is also one of the chemicals in the reaction called Photosynthesis.
How does the plant take the water from the earth to the starch factory in the leaves?
Look at and read about Slides 4 and 5 and do Exercise

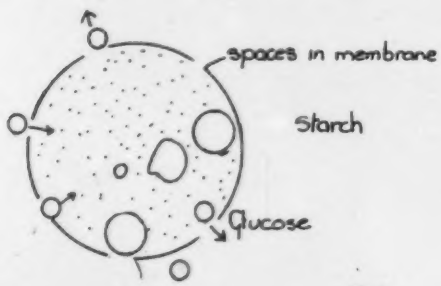
Draw a root hair growing from a special cell of root tissue. Draw the water carrying tubes in the root. Label them vascular tissue (veins)

5 Look at slide 6. Have you done a similar experiment? Write an account of the experiment (see page 63.) in Exercise 20

6 Now that you have seen starch grains on your bioviewer, it will be interesting for you to see where the plant may send the food to be stored.
In slide 7 you will see it as an energy supply given to a pollen grain to help it keep alive when it is travelling and slide 8 shows a potato 's food store.
A potato is a swelling in a root of a potato plant.
The eyes on a potato can grow into leaves and stems.
Although a potato is not a seed, the plant has provided for a new plant in a different way. Answer all the questions on your Bioset in Exercise 21

Why make starch at all?

Most plants make glucose and then turn it all into starch. Why don't they keep their food in the form of glucose? The reason is the size of the molecules. The large molecules of starch cannot go into solution and pass out of the tiny holes in the cell membrane. While the plant is very busy in daylight making food in its leaves, it is more convenient to store its food as starch, because it stays in one place. When the food is needed elsewhere in the plant, it changes it back into glucose (using enzymes) and moves it around the plant.



It can be understood that, as in our lungs, a large surface area is necessary on a plant so that it can:

1. Obtain enough carbon dioxide for its needs from the small quantity present in the air.
2. Gain sufficient light for photosynthesis -

Activity 6 Finding out about the surface area of leaves

How large an area is held out to the light by one small plant? You may be surprised when you find out.

Photosynthesis is very important to all living things. Without it, there would be no food for the plants themselves, and certainly none for animals.
The energy from the sunlight is contained in all the food eaten by all animals including ourselves!

One member of your group should fetch a small weed having about 20-30 leaves.
Pull it from the ground and shake the soil off the roots.

1. Count the number of leaves. Record this number.
2. Remove the leaves and share them out among the members of your group.
3. Try to make a guess of the surface area of all the leaves on the plant.

Is the surface area of your plant about the same as that of your Zim-Sci book, your desk top, your teacher desk top or your blackboard?
Write down your guess.

4. Over the page you will find some $1cm^2$ squares drawn for you.

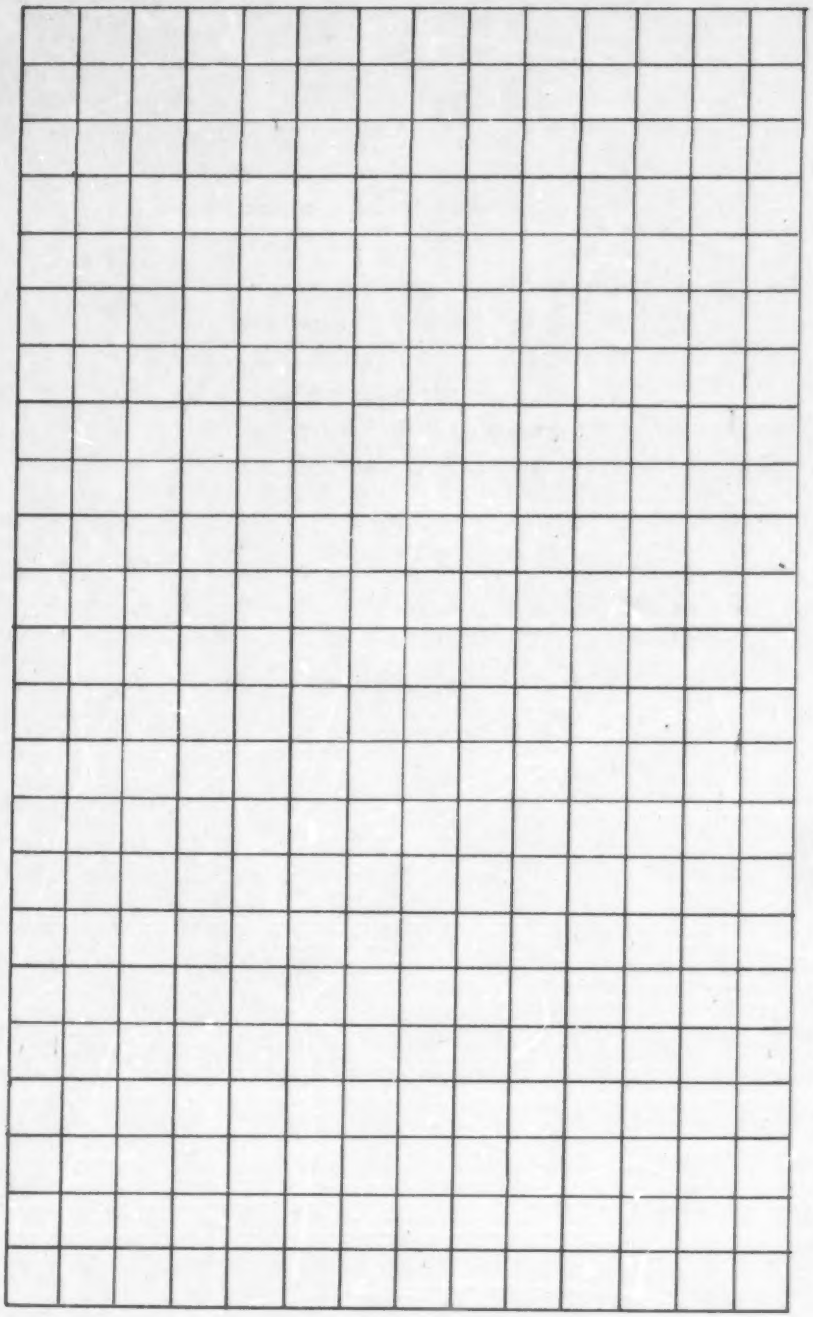
Each pupil should calculate the surface area of his or her leaves in this way:

(a) place the leaves on the squared paper;

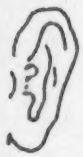
(b) draw around each leaf lightly in pencil so that it can be rubbed out afterwards;

(c) Remove the leaf and count up all the squares covered by the leaf. 1 square is 1 cm^2. Count each square more than half covered as 1 square. Do not count any square less than half covered. As a leaf has two surfaces, you must double your answer.

When all the members of your group has worked out the surface area of their leaves, add them all together. Is your total at all like your guesses?



You have discovered that both plants and animals have special organs for exchanging gases. Animals always use up oxygen and give off carbon dioxide, plants do the same in the dark when they cannot photosynthesise. They respire, getting energy from their stored carbohydrate fuel.



Discuss with your teacher how you could set up an experiment to show that plants respire.

In day light, when plants are making food, they do still respire, but they photosynthesise much more quickly. So they give off a lot of oxygen and use up a lot of carbon dioxide. Their special organ for exchanging gases are leaves.

It would be interesting for you to compare the inside of a leaf with the inside of a lung!

Activity 7 Comparing the tissue inside a leaf with the tissue inside a lung.

You will need

Bioviewer
Bioset ZS/5

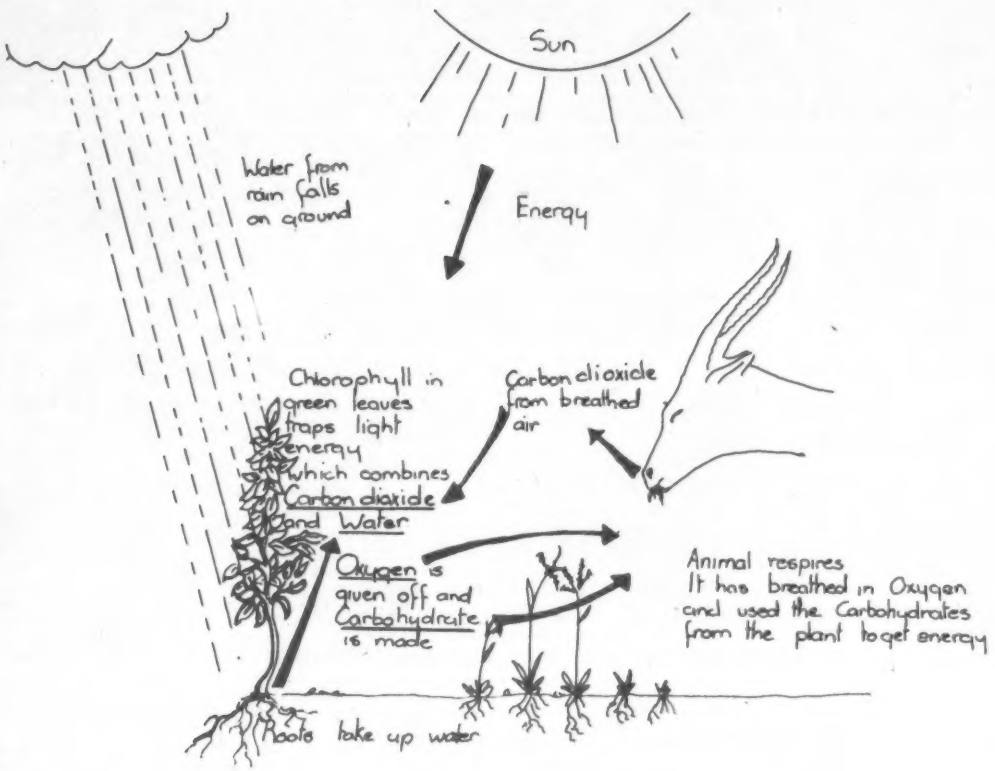
Look at slides 2, 3 and read about them.

Look at slide 5 and read about it (a capiliary is a small bloodvessel).

Answer questions 3 and 5 on the bioset.

You have, in your experiments, found out what happens during Photosynthesis.

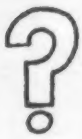
Photosynthesis is very important to all living things. Without it there would be no food for the plants themselves, and certainly none for the animals. The energy from the sunlight is contained in all the food eaten by all animals, including ourselves, and is the energy all organisms use for living.


Sun
Water from rain falls on ground
Energy
Chlorophyll in green leaves traps light energy which combines Carbon dioxide and Water
Carbon dioxide from breathed air
Oxygen is given off and Carbohydrate is made
Animal respires It has breathed in Oxygen and used the Carbohydrates from the plant to get energy
Roots take up water

A picture summary of Photosynthesis.

You should now read and revise Part II of this Unit, then do 'How much do you know?'

HOW MUCH DO YOU KNOW? PART II



1. Photosynthesis is: the process by which ..... are made by ..... from ..... and ..... using ..... energy.

2. We can test to see if a plant is taking in ..... using ..... indicator.

3. A plant gives off ..... gas into the air. This is left over during photosynthesis and is used by animals to .....

4. Animals give off a waste gas ..... which is used by plants to make .....

5. The important green colouring which ..... light is called .....

6. The water needed for photosynthesis is obtained from the ..... through the ..... of the plants.

7. Lungs and leaves have a large ..... for the ..... of gases.

SUMMARY

Food contains potential energy.

The energy in food can be released in a reaction with oxygen when organisms respire.

Carbon dioxide and water are waste products of respiration.

Heat is usually given off as part of the energy released during respiration.

Plants containing chlorophyll trap light energy from the sun and convert it to potential energy stored in carbohydrates.

Carbohydrates are a group of compounds containing carbon hydrogen and oxygen.

Simple sugars have small molecules and can be built up into larger molecules of sucose, starch and cellulose.

Enzymes are substances which help break down or build up certain food molecules.

During digestion large food molecules are broken down into smaller ones by enzymes.

The change in volume in the lung during breathing causes changes in pressure. This means that air is inhaled and exhaled from the lungs.

Air passes in and out of the leaf through stomata by diffusion.

Lungs and leaves have large surface areas for the exchange of gases. Chlorophyll is in the form of chloroplasts in the cells of the leaf.

During photosynthesis carbon dioxide and water are joined together in a chemical reaction to form carbohydrates. Small molecules of glucose are formed first, then converted to starch for storage.

All living things respire all the time.

During daylight plants give off excess oxygen gas as a waste product.

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